ELECTRONIC TRAVEL PASS

BACKGROUND OF THE INVENTION

The present invention relates to a portable private database in pocketsize format outwardly resembling a pocket calculator and combining a number of inventive characteristics in order to obtain a few important results. Replacement of on-line transactions by secure off-line point of sale transactions. The device should have a long working life. The user should have access to his data at any time without the cooperation of a terminal. During a transaction, the device shall remain handheld to avoid the delays associated with machine-fed read positions.

Insofar as this invention is concerned, we shall refer to the private pocketsize data base as a "travel pass," because of the term's brevity and the expected outstanding utility it may come to have for mass transportation applications. Some of the ideas underlying the present concept of an "electronic travel pass" have already been defined by the present author, especially in United States Patent No. 4,661,691 (Proximity Data Transfer System) or United States Patent No. 4,499,556 which deals with the problem of security for long-life cards, or United States Patent No. 4,906,828 which describes data entry on the card itself, and which describes a simple scrambling circuit for protecting the secrecy of the data interchanged between a card and a transaction Reader.

SUMMARY OF THE INVENTION

Further inventive effort was necessary to provide a "travel pass" with greater data transfer speed; to protect the integrity of the data in face of exterior electronic noise or interference; to enlarge its usefulness; to enable

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the owner of the "travel pass" to select his/her secret PIN and to change it at any time, without the assistance from a second person or office; to convert a travel pass which normally can only communicate with a terminal at close proximity, into a radio-responsive card capable of passing on its serial number

5   or account number over a distance of several feet.

BRIEF DESCRIPTION OF THE DRAWINGS

Descriptions of these various aspects will now be given with the aid of illustrations and drawings, wherein:

10   Figure 1 shows a block diagram of the basic components of a travel pass card according to one embodiment of the present invention;

Figure 1a shows a conceptual view of a front surface of a travel pass card according to the present invention;

Figure 1b shows a card with two embedded capacitive antenna plates

15   and a data retrieval circuit associated with them;

Figures 1c – 1d are equivalent circuits explaining data transfer by impedance changes;

Figure 2 shows an example of the wave forms at different parts of the circuit;

20   Figures 3, and 3A-3D show portions of the signal circuit of the card reader unit, which is largely a mirror image of the circuit of Figure 1b;

Figure 4 indicates the modification of the Figure 1 circuitry where in place of the capacitor antenna a flat spiral coil is laid into the card and reader, respectively;

25   Figure 5 illustrates the basic schematics of a "travel pass" combined with a modified form of the Figure 1b circuit;

Figure 6 shows a reader and proximity-operated card or "travel pass" with a very simple data retrieval circuit connected to a Motorola CMOS microcomputer chip. In this design, the square pulses inputted in Figure 1b,

30   are now replaced by VHF sine waves applied to the same twin capacitor plates in anti-phase;

Figure 7 shows a string of a sine waves used for data modulation, and the string of ß sine waves used for producing timing pulses;

Figure 8 represents an example of logic levels transferred to the "travel pass" as data and logic levels applied to the "travel pass" computer chip as clock pulses;

Figure 9 shows again the clock pulses (CK) and the (α-3) output from the differential amplifier representing data transferred from the card to the reader;

Figure 10 shows two spiral coils connected in phase, to satisfy the condition for cooperating with short-distance proximity readers; they are connected via switches in such a manner that they may work in anti-phase with the reader emitters, and that makes them suitable for working in phase with a radio transmitter at a modest distance;

Figure 11 shows the effective card circuit when the switches are in one position;

Figure 12 shows the effective card circuit of the coils when the switches are in their other position;

Figure 13 shows two spiral coils connected in phase for short distance readers, but in anti-phase for any 'common mode' signal (usually a noise signal);

Figure 14 shows the same arrangement of coils as in Figure 13, but the coils are implanted into a silicon chip whereby the upper chip has in the center of the coil an integrated minicomputer, and the lower chip has its center solid state integrated semiconductor switches;

Figure 15 is a block diagram which relates to a fare collection system for use with "travel passes" and relates to program structure for testing the travel pass for various criteria before deducting a fare, and, if the residual value is inadequate to cover a minimum fare or the required maximum fare respectively, the control system puts into operation an updating unit after checking a blacklisting register;

Figure 16 is a flow diagram for operation of the system of Figure 15 in the case of flat fare debiting:

Figure 17 is a flow diagram for graduated fare operation of the system of Figure 15;

Figure 18 is a block diagram, and Figure 19 shows a perspective view of the "travel pass" according to another embodiment of the invention;

Figure 19a is a detail of the display window in the card wherein the contrast of the display is improved by a light L derived from a light source in the reader unit;

Figure 20 shows a "travel pass" circuit wherein the electronic value memory is provided by a standard size smart card inserted into the said pass;

Figure 21 is a perspective view of a travel pass with a facility to accept a card-like prepaid cash component;

Figure 22 shows another type of provision for electrically connecting a standard smart card to the "travel pass" device;

Figure 23 shows a further detail of the "travel pass" device;

Figure 24 is a cross-section of one of the four or five spring loaded contact pins;

Figure 25 shows an example of a keyboard with numerical and functional keys such as a "universal travel pass" might be equipped with;

Figures 25a and 25b are perspective views illustrating the operation of a "travel pass" device according to the present invention;

Figure 26 provides a guide for the use of the keyboard of Figure 25;

Figure 27 is a logic flow diagram for various optional preparations which the user of a "travel pass" would make dependent on his intentions or anticipations of usage; and

Figure 28 is a flow diagram of various optional procedures for using a travel pass at a vending machine or a market point of sale desk.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For may applications, but especially for certain forms of fare collection, it is very important to reduce the total transaction time, and that can not be done unless (a) the data transfer speed is stepped up substantially, and (b) the card remains handheld during the period of the transaction. Ideally, a passenger on mounting a bus need not do more than holding his travel pass against the surface of a read/write unit for a brief period of time during which all the necessary card checking and updating is performed. Alternatively, the travel pass is briefly inserted into wide open acceptor area (such as a shallow slot) where wide tolerances permit easy and rapid insertion and withdrawal of the card device.

A fast synchronous data transfer circuit is hereunder described. The synchronization between the operation of the checkout unit and that of the travel pass electronics is obtained by a new approach. The proposal also includes protection against random noise.

5   To begin with, Figure 3 shows the approximate mutual position of the emitter plates 1 arranged on the read/write terminal, and the corresponding antenna plates 3 arranged on the backside of the "travel pass". The spacing between the metal plates 2α and 2β, and the metal plates 4α and 4β would be between 5 to 30 millimeters. The α line carries square pulses and so does the

10   β line but 180° phase shifted against the former.

Figure 3A illustrates the manner of interfacing a travel pass with a transaction terminal: By holding it against the reader plate RP.

Figure 3B shows an interface terminal with capacitive coupling for use with a thin memory card or smart card.

15   The card C is inserted into a slot made of plastic material P internally lined with two metallic layers insulated from one another except that they are both connected to input bonds of the LSI chip CH. Each of said layers encompasses the slot gap on both sides forming a kind of Faraday cage into which the card is dipped. The drawing Figure 3A shows these layers (α -2,)

20   and β-2) in cross section. The internal width would be only marginally wider than the thickest card or travel pass to be employed with that type of Reader terminal.

The card itself may be thought of being made of three sandwiched layers, the outer and middle layer, the latter being cut away to make room for

25   the LSI chip. The same is a microcomputer with only two connector bonds, for connecting to the two-transducer elements (capacitive plates or inductive coils). The same chip may also accommodate the extra logic for the scrambling/descrambling of the incoming/outgoing signals and for any extra switching functions, which the proper performance of the described system

30   requires. "W" is an optional LCD window.

An advantage of the described configuration of the capacitive lining on a slotted reader unit is that a good coupling factor is obtained with the prospect of injecting enough power into the card or travel pass for powering the LSI circuit CH as well as the liquid crystal display showing the latest

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balance held in the pass, retaining it legible for up to one minute after a transaction. Inexpensive, non-processing read-only readers can also be provided as a complement to the overall system where the public may obtain a quick status readout without having to occupy the time of a transaction

5   device.

Figure 3C provides an indication of the data transfer circuitry in the card of Figure 3B.

The card C is again shown partly surrounded by the transfer elements (α-2) and (β-2). They are connected to voltage amplifiers A via resistors R,

10   driven by logic level square pulses CLK. If there are no outgoing data pulses do from the reader unit, the pair of capacitive plates are charged and discharged by a train of high frequency pulses of same shape, phase, frequency and amplitude. These electrical conditions will, mirrored by similar voltage changes in the card transfer elements (α-1) and (β-1) within the card.

15   The rectifier diodes cause a build-up of positive and negative potential on the operating rails of the chip circuit. This causes a brief transitional charging period, sensed by the reader circuit by means of the comparator CO across the resistor R as shown in (Figure 3B). The simultaneous rise and fall of the input potential (β-1, α-1) on both input terminals of the comparator dA (Figure

20   3A) will not cause any adequate output from this comparator circuit. The differentiator D generates a strobing clock pulse for any high level applied to output terminal Di so as to clock serial data into a buffer register provided in the microcomputer circuit of the chip CH (Figure 3B). When said buffer register outputs a high level data bit it is applied to AND gate G which is

25   enabled only during a high-going data bit by means of a simple S/R bistable. The output therefrom is applied to the gate of a field effect transistor TR whereupon the plates (α-1 and β-1) are short-circuited for the duration of a single clock pulse. In the reader circuit, this causes a voltage drop across resistor R and an output wave Di from the comparator circuit CO. The logic

30   circuitry on the left is needed to change the input α-2 in such a manner that the differential amplifier dA in the card circuit produces a data bit output (Di) for every data bit output (do) on the reader side.

Figure 2 contains 12 voltage-time diagrams. On rows 1 and 2 the input signals 2α and 2β are shown. The voltages that arise from the reactive

transfer on the meal plates 4α and 4ß respectively would be similar to those shown on rows 1 and 2, respectively if the impedances of leakages to quasi-ground level were very high, say 50 MΩ. At lower bleeder resistances, say 5 Mohm, the differentiator effect comes into play. See row 3 for the 4α pulses.

5   The transfer circuit is shown in Figure 1b. Ti 1 and T2 are field effect transistors.

The general data transfer parameters can be described as follows: Each data binary bit is embedded in one of three clock pulses; more accurately, it is embedded in the second one of three clock pulse positions. If

10   a number contains many zeros, the monotonous flow of clock pulses continues unchanged. The clock pulses occur in groups of three, counting a, b, c – a, b, c, etc. A data bit can appear only during the part period 'b'. A logic one is represented by the absence of a clock pulse during period 'b'.

The basis of synchronization is the two-bit counter using two D-type

15   bistables III and IV. In our example, the repetitive count is given by the states 1,2,3; the state 0 is skipped, using 'and' gate 6 for this purpose. A high data bit to be transferred from the card circuit 100 to the reader unit must pass through the AND gate 9, which is enabled only during the 'b' period (count 2) of the counter. If the data to be transferred are held in a shift register, the shift

20   clock is obtained as an output from the NAND gate 7 at the beginning of each 'b' period. Any high output from the AND gate 9 is applied to the control gate of the transistor T3, which then virtually shortens the capacitor plate 4α to a reference level, quasi ground level. As a consequence there is a low resistance path from the plate 4α to the plate 4ß which amounts to a drastic

25   reduction of impedance to the supply line of the 2α input pulses. As a consequence, there will be a major increase in the load current across the resistor Rα in the reader unit. This is detected by a sensor element dA and used in the further circuitry of the reader unit to represent a logic "1" level in the reader computer.

30   The data transfer in the opposite direction, from the reader to the card, is done as follows:

As can be seen from Figure 3, a high data bit is applied to the gate of transistor T6 which virtually eliminates during time period "b" the clock pulse potential on the capacitor antenna 2α. As a consequence in Figure 1b, this

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eliminates any voltage on gate Gα so that the reset potential of input point R remains high and the already set bistable I remains set with QI output being high. These conditions can be followed through also on the voltage-time curves of Figure 2: On row 4 the gate Gα suddenly does not receive the

5   regular spike, nor does the negative going reset spike develop on row 5 (Ckα). The bistable output QI (row 7) changes from producing square pulses to remaining high over a period of two pulses. This also affects the next bistable II output, row 9. Strobed by clock pulses CKβ2, QII goes now high shortly after the beginning of time period 'b' and remains so until shortly after

10   the end of period "b". To obtain a data output, which is clearly cut off at the end of the period 'b', one would have to provide extra gating but this is in practice not needed. The small overlap is not of any consequence. The output of AND gate 5 represents a strobing spike roughly in the middle of each time sector (a, b, c), and therefore, the downstream circuit (the card circuit) can

15   use this spike for clocking the data (Q II) into its register.

Finally, if the reader computer routine wise emits a reset signal to ensure that all the registers and bistables of the receiving circuits are cleared before passing on a command, etc. This can also be done by means of the present interface circuit. In this case, after the first data bit is sent in time

20   sector "b" another data bit is applied immediately following in time sector "c". This keeps the data output on line 9 of Figure 2 high over the time periods 'b' and 'c'. The CKß1 spike during the middle of period 'c' is a unique pulse useable by the downstream circuitry as a reset pulse. It is obtained as an output from the four-input AND gate 10 in Figure 1.

25   Figure 4 shows essentially the same circuitry when in place of a capacitor plate an inductive coil (2α-4α, 2β-4β) is used. Such coils are preferably configured as spiral coils on printed film. When a logic "1" is to be sent from the reader to the travel pass (card) the clock pulse in time sector "b" is stopped by the transistor T7 of the PNP type, while the NPN transistor T8

30   shortens the coil to ground to ensure that no noise spike gets through during period 'b'.

Figures 1c and 1d make clear how a data pulse is transferred. High frequency clock pulses are applied in opposite phases to terminals α and β. When the switch is open the load is 3 MΩ, when closed it drops to a few

hundred Q. The capacitor plate on the left having been at normal alternating voltages, now drops to near zero.

It remains to describe the manner by which the reader circuit which is essentially identical to the card circuit in Figure 1b, synchronizes its counter with that of the card (and vice versa).

It is already understood that the terminal and the data card (travel pass) send out a data bit only in the counter period 'b'. It is now assumed that the receiving party's counter circuit is at that moment not in the 'b' period but in the 'c' period of its triple cycle. A high data bit received in Figure 1b will cause, as explained, the bistable II to go high, virtually at the beginning of time section 'b' in the sending circuit but arrives, according to the present assumption in time period 'c' of the counter in Figure 1. What happens is simple this: Q of the bistable II, having previously been high goes low, applies a low-going pulse to capacitor C2 and thus does the same to the setting input of counter bistable IV as well as to the resetting input of the counter bistable III. This puts the counter immediately back into its time period 'b'. The same would happen if a data bit is sent to the reader circuit, and its counter were not synchronized; the very sending out of a data bit is therefore the synchronizing agent.

As Figure 1b shows, the circuit can also be used for charging a capacitor "Co' via rectifier diodes d1 and d3. The charging of this capacitor Co as well as the current load imposed by the integrated circuit have the same effect as the resistor R1; these will cause a more or less gradual decline of the induced voltage. Accordingly, the resistor R1 may be omitted. Also, resistors R2 and R4 should be made no lower than needed for operational stability.

If the "Travel pass" is powered by a battery (if the pass comprises a display a battery will have to be included in any case) and the differentiator resistors are omitted, the signal form applied to gate Gα will be virtually the same as the input signal. Even in that extreme case, the circuit of Figure 1 will function precisely as described.

As the "Travel pass" transaction card is intended to be handheld during a data transfer, it is important that any stray field emanating from the hand does not affect the data integrity through distortion or one-sided

superimposition of static potentials.

A method for making common mode signals harmless is to apply to both the α and β channel identical input signals but of opposite polarity, and, at the receiving side apply them to a differential amplifier dA. This is shown in

5 Figure 5. Since in this version both the imput channels (α, β) are used for the data input, the clock signals must somehow be derived from the data stream itself. This is performed in the clock pulse emulator circuit that uses a digital phase-locked loop. Figure 5 indicates this circuit group as a functional block.

The card 3 contains embedded in it not merely the active metal plates

10 4α and 4β, but also a shield plate 3a. A purpose of this plate is to ensure that the static potential induced in it from external sources is equal at all points and will thus elevate or reduce the potential of the aforementioned active metal plates by the same amount.

In the lower part of Figure 5, the remaining component elements of a

15 "travel pass" are shown, namely the liquid crystal data display, the group of data entry keys, and the micro-computer chip which contains not merely the processor but also the various data registers and memory banks. The main input and output ports of the microcomputer are also indicated which link with those of the interface circuit above. The just described circuit is reckoned to

20 be capable of transferring data at a rate only one-third of the injected carrier. Using another interface circuit described below, only much lower data transfer speeds can be achieved.

As Figure 6 shows, the card (3) contains again two metallic layers 4α and 4β. These layers may be either a thin metallic deposit or may have the

25 form of a spiral coil. In the second case, the arrangement of the circuit would follow the indications of Figure 4. Using a high rate of change induces field changes in the immediate surroundings of the capacitor plates (or of the two spiral coils 4α and 4β) sufficient to produce the operating voltages and currents in the IC circuit of the card. In this present design, however, the

30 periodicity in channel α and β is the same but opposite in phase. That means with increasing distance from the. signal source (the reader-emitter), the field forces nearly cancel each other and would 15 thus have no effect on the card receiver antennas at read-card distances of more than a few inches. When the operating voltage in the card has risen to an adequate level, its micro—

computer 7 is programmed to produce an output at Pao of chip 7 (Figure 6) with the clock pulse applied to it. This is applied to AND gate 5 in Figure 6 whose high output pulse makes the transistor 8 conductive, thereby producing a short pulse in the reader circuit. This pulse serves as a start signal for the

5 reader computer unit to commence 25 its program of data interchange.

Figure 8 shows the envelope of the waves for the data sequence 0-1-0.

Figure 9 shows a data bit at the output of the differential amplifier 6 in the reader unit, demonstrating the principle of data flow from card to reader.

Also, for this second version of a proximity data transfer, the principle

10 of a fully balanced twin-input can be realized as for the preceding example in Figure 5. Again, the clock pulse channel must be replaced by an inverted second data input channel while the still needed clock pulses are to be derived from the data stream itself. This is facilitated by converting the binary code into the well-known Manchester code from which the clock pulses can

15 be derived.

A "travel pass" to be universally useable, ought to be able to be used also for the automatic paying of parking fees and road pricing fees.

It would indeed be possible to use the "travel pass" to these ends; 'if applied to the metering of road usage, however, the delays due to cards

20 having to stop at entry and exit ramps may lead to the build-up of queues. Moreover, at exit ramps such delays could be dangerous because they may cause blockage of the neighboring fast freeway lane. It would, therefore, be desirable for electronic checkpoints to read a "travel pass" at a distance. Financial transactions at a vending machine or market require the very

25 opposite working conditions. Cards should be readable only at close proximity and reject all signals that derive from any distance beyond a few inches. It would therefore seem that a "travel pass" could never satisfy the above contradicting requirements. However, this need not be necessarily so if one envisages the use of (electronic) change-over switches integrated and

30 incorporated into the card circuitry. It would then be possible to enter logic commands via the data entry areas on the "travel pass" to operate said change-over switches.

With the aid of Figures 10 to 14, the possibilities that derive from switched sensors, will be explained.

Figure 10 shows coils 1 and 2, and capacitors 3, 5 and 4, as isolated components connected only to change over switch elements 5,6,7 and 8.

Figure 11 shows two oscillator circuits operating independently from each other, whereas in Figure 12, the two systems operate as a single resonance circuit. The resonance frequency in the two cases need not be the same. In Figure 13, the two resonance systems deployed on the same card substrate work in one switch position in counterphase, in the other switch position in phase. It is also possible to embed the coil conductors as very fine lines into a silicon substrate, with very accurately dimensioned spacing between the coil windings. The inter-wire capacity together with the inductance acts as an oscillator circuit. The switches 26, 27 and 28 can be used for changing the relative phasing of the two systems. When the flux is as if from a source (23), it is a sink—flux (24) in the other coil, and vice versa. If the switch is changed over, the two coils have uniform flux changes. The changeover switches may also affect additional capacitive elements if a change of frequency is desired.

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as if from a source (23), it is a sink-flux (24) in the other coil, and vice versa. If the switch is changed over, the two coils have uniform flux changes. The change-over switches may also affect additional capacitance elements if a change of frequency is desired.

5   Those two factors, phase change and frequency change, will permit good separation of the two operational versions, the close proximity one and the moderate distance one.

It has already been mentioned that the switches can be provided in solid state form. In the execution of Figure 14 the card comprises two silicon 10 chips, one for the microprocessor and memory, the other for the switch logic. The surrounding area in both chips is used for the placement of the inductive coils 21 and 22, respectively. Manual switches (A,B) arranged on the card cause the microprocessor to generate control signals (1,r) dependent on whether the user intends to make a POS transaction or a parking or road 15 pricing transaction. Pin size LED's (AA, BB) would indicate at all times which mode is in operation.

The switch logic may be combined with the microcomputer chip on the same substrate. In that case, the I. C. may be placed between the two coil areas.

20   So far, this paper discussed the important aspects of signal exchange between a "travel pass" and a reader unit. Next, a programming feature to be incorporated in the "travel pass" is to be described, supported by Figures 15 and 16, which are event flow diagrams.

The program principles to be discussed relate to the general area of 25 payment of fares by a card system, especially at the critical moments when a fare is due but the residual value of the card proves to be insufficient. The principle explained will be particularly useful for revenue collection on buses, but would also be very useful in other small payment situations.

It has long been known that cards can be used as a voucher of credit 30 issued by financially stable institutions (such as banks or building societies). Although, the credit issuing company, debits the buyer or the seller, or both, in return for pledging payment, with a certain percentage of the moneys advanced, the procedure often includes a review of the card owner's accounts to see whether credit worthiness still exists. Sometimes it is necessary to

transmit the numbers of blacklisted cards directly into a register close to the point of transaction. An example for how this can be done and how credit cards can be tested as to their validity, is given in U.K. Patent 2 057 740B.

Assuming that equipment of this type is available on a bus, there exists also another technical difficulty affecting the cost efficiency of credit card debiting on public transportation in an urban area: It is the sheer number of transactions that occur. The average value for each such transaction is low, say about $1.20, yet for each 'such transaction sufficient data have to be transmitted to the bank computer of the customer's bank to obtain payment. It can easily be seen that the normal routine for credit card payments such as come into play with the purchase of capital goods, is not applicable lest the overheads would become too large.

Faced with this inapplicability of prior art of credit card payment to fare collection the present invention provides for measures and card processing software which intend to make its use in travel available for both the daily commuters, occasional travelers, in short for a substantial majority of the traveling public.

This aim is proposed to be achieved by combining the aforementioned electronic register for blacklisted numbers, with an accumulator of fares the same would cause the latest fare to be added to the sum of preceding fares derived from the travel pass, and then updates said sum in the card memory. Every time the traveler's card is presented to a transaction terminal, it reads from the card the sum of earlier fares, adds the current fare, and 'then compares the new sum with a preset number in a separate register of the transaction unit. This last-mentioned register is non-volatile and represents a reference level with which the value level of accumulated paid fare memorized in the "travel pass" plus the fare that would be payable for the current trip is compared. For the purpose of explaining the idea, it should be assumed that the comparison shows that the sum of all fares exceeds the reference value level. This condition triggers another program set in the transaction programming' unit which:

(a)   deducts from the reference value the amount by which the sum of all fares exceeds this value;

(b)   the then remaining value is entered as a refreshment update

into the value register of the "travel pass".

(c)   the account number of the "travel pass", together with the bank code and interbank fund transfer phone number are being read out from the "travel pass" and transferred to a register in the transaction unit.

5   Throughout the entire regional transportation system the above cited reference value is the same, in other words, all travel passes are at all times updated by a constant value, in some cases by a multiple of that constant value. This arrangement does not only permit the process to be automated, but also reduces the quantity of data that have to be processed, both by the

10   transport operator's computer plant and by the various banks who participate in the project. From the ordinary traveler's point of view, this scheme has the advantage that he/she need not worry about fares exceeding the balance in the travel pass which, in other circumstances, may mean interrupting the journey and trying to find a branch of a suitable bank for updating the pass, or

15   a person has to carry enough cash to have the pass updated by the bus driver or the local ticket office, etc. If the "travel pass" requires updating during a high peak hour, or at a moment when a train has to be boarded, this can be highly inconvenient. Some bus drivers may refuse to do any updating during rush hours. It would be an all-round inconvenience to all concerned and

20   reduce the efficiency of the transport system. The new method would in practice mean that on an average 10 times fewer data transmissions need be carried out each day; the cost of the credit system would go down to acceptable levels. Also, transport companies will receive easily auditable bulk payment for their services to the public made directly by banks to their

25   corporate bank accounts, bypassing all paperwork and the handling of coins and bank notes, checks and vouchers. The considerable overheads implicit in fare collection today, can be reduced. In addition, the very drastic reduction of boarding times would reduce turnaround times which amounts to a better service to the public.

30   The feasibility of the envisaged performance can best be understood. with reference to Figure 15 in which the interactions between the "travel pass" 20, the transaction unit 1, a depot computer 14 and a central clearing computer 19 are represented by functional block diagrams. The card reader consists of a plate containing a wire loop' (or capacitive plates) 3, an

optionally provided lamp 2, and interface circuit 5 for preparing signals for transfer to the card 20, as well as for receiving and adapting signals coming from the card for entry into the microprocessor 7. Between the units 7 and 5 may be provided a scrambling unit 6 which ensures that vital data, such as

5   the systems protection numbers, can not be deciphered by means of radio equipped clandestine analyzers. An example of such an encryption/decryption circuit has been given in the Published Patent GB 2 130 412B. The microprocessor 7 passes the serial number of the card 20 obtained via the reader 3, to the circuit group 8, which contains the means for

10   comparing the serial number with all the blacklisted numbers of the local traffic region. This is done at a high clock rate.

      If any of the numbers contained in the blacklists of block 8 is equal to the serial number of a card being processed, the unit 8 emits a flag signal through its connector line 7-2 and causes the microprocessor 7 to change its

15   program and produces a display on the driver's console 12 and/or activates a buzzer or the like, and also extinguishes the Lamp 2 (Lamp 2 may be used for illuminating solar cells fitted on the "travel pass" card 20). . The driver will request fare payment 1 cash, or request update of the card against cash.

      Assuming the card is not blacklisted, the next step would be to assess

20   its genuineness. This is done by a procedure described in GB 2 092 344, a published patent. The procedure is recapitulated in the flow diagram Figure 16. Returning to Figure 15, the scramble unit 6 and the register 10 are assumed to be contained on the same silicon chip together with the processor circuit 7 so that no external connection line is required to carry the secret

25   protection number in clear form. This is essential for the preservation of secrecy.

      Block 9. is important for our purposes in the present invention. It is a register holding the number which represents a value level to be compared with the accumulated fares since the last update of the card. If there is an

30   excess of fare debts over and above the said reference number in block 9, a program in the microprocessor is started which:

      (a)   deducts from the accumulated fare debts the fixed number in register 9.

      (b)   enters into the register 11 the card serial number of the card 20.

No further additional data need be entered into register 11 in support of the serial number since the very fact of a recording of the serial number in register 11 is equivalent to a constant debit as prescribed by unit 9. This level, as already indicated, is the same throughout a given transport region, and would also be agreed with the banks in that region.

When the bus arrives at the depot 14 at the end of the day's shifts, the bus personnel establishes a connection between the transaction unit 1 and the depot computer 14, which then controls the transfer of all the serial numbers of cards which underwent the described update procedure. The data transfer is preferably done via an optical cable link 15-8. On this occasion, the, most recent compilation of blacklisted serial numbers are entered by the depot computer into the on-vehicle register block 8.

Between the late hours of the day and the early morning hours of the next day, the depot computer translates, based on prepared look-up tables, the serial numbers received from register 11 of the transaction units of buses into the appropriate account numbers which are then sorted by bank codes and branch numbers, enabling a computer to transmit the 'list of units debts to the various head office computers of the participating banks. While thus the individual accounts of various transport patrons are being debited with the said units charges in favor of the banks concerned, each bank will arrange to send to the various transport depot computers 14, 14', 14". The amounts due to the various fleet owners. This last-mentioned step can be omitted, if the various vehicle operators opened bank accounts with the major banks of the region. Thereby, further savings can be achieved.

Figure 16 shows a flow diagram for the sequencing of the just described processing steps in cases where fares are always straight flat fares pre-payable at the entry of a vehicle or a station platform.

Figure 17 is a flow diagram for graduated fares. Section "A" in this flow diagram is identical with that shown in Figure 16, and is therefore not shown. The diagram also illustrates the differences for railways and buses.

The processing of graduated fares on public transport systems is within the public domain (see U.K. Patent 857,658) and need therefore not be described here. That early publication prescribes the use of magnetically encoded cards, whereas the present paper relates to electronically encodable

data components endowed with processing capability within the cards. Compared with the apparatus of the old technique, electronic readers are very small and can be clamped to a support rail or side wall and therefore need much less space which in busses is at a premium. Passengers need not

5   enter the card into machine. The technique used in a "travel pass" is such that the traveler has to hold the pass briefly against the "reader" plate. While the new data transfer technology employed in "travel passes" (see U.K. Patent Application 9 115 408.8) makes possible the mounting of readers close to entrance and exit doors of buses, there is still doubt whether the same

10   technique can efficiently be combined with turnstiles.

One way for dealing with the problem of graduated fares on buses would be to charge the passenger when he boards the bus, for the entire remaining route of the bus, but, when the passenger checks out at the exit door, he is refunded the excess of the paid fare over the proper fare to the

15   point of exit. However, this method does not exclude that a passenger may choose to check out his/her pass ahead of time, long before he actually leaves the bus.

It is therefore proposed that the following alternative procedure is used on long-distance bus routes: The passenger pays upon entry the fare for the

20   whole distance until the end of the line. No equipment is provided for checking out at any of the exit doors of the bus. Instead, all the stops along the route are fitted with so-called "refund units" where passengers, after leaving the bus vehicle, can obtain refund for any excess fare they paid when boarding the bus. The electronics of these "refund units" would be fully

25   protected by the systems check numbers and the scrambled communication system as described in GB 2057740 and GB 2092344.

In this context, a fully automatic fare collection procedure for long-distance bus lines can be effectively realized without any possibility for fraudulent misuse on the vehicles.

30   Having described the "travel pass" in some detail with respect to its inventive techniques for communicating with a read-write unit, as well as some of its inventive features in its data processing programs, the further description of the travel pass will now reveal the innovative structures, electrical and mechanical; reference will now be made to Figures 18, 19, 25 to

28.

Figure 18 illustrates the basic electrical building blocks of a travel pass (at times also called "smart purse"). There is a microcomputer 1, a push-button aggregate 2, and a display window 3 with its drive circuit 4, a battery 9,

5   and a voltage stabilizer circuit 5 to produce the operating voltage for the microcomputer within the required tolerances, and an antenna 7 cooperating with an interface circuit 6. The latter may also comprise a scrambling/descrambling and security circuit 6a as for example described in full detail in GB Patent 2,130,412. In place of an electromagnetic radiation

10   element 7, also optical devices may be used for producing the field disturbances interpretable as data. Equally, plain capacitive coupling elements such as described in the United Kingdom Patent Application Serial No. 9115403.9 and application Serial No. 9122242 may be used.

Figure 19 shows the top part of the data carrier 10 with numerical data

15   entry buttons 2a, and functional command buttons 2b, and a special sideways mounted button 2c (for use by the thumb of the right hand holding the device in front of the reader surface). A display window using liquid crystal techniques 3 provides feedback to the user. Two holes 11 permit the device to be suspended in a vehicle permitting data to be read while the vehicle is in

20   motion.

Figure 19a shows a possibility of rear illuminating the LCD display during or after a transaction. See also Figure 24. The LCD glass plates are sandwiched between two parts, 10a and 10b, of the purse device. Part of the rear surface 10d may be used for electricity generating photosensitive layers.

25   A capacitive antenna plate 10p may be embedded in the plate 10a to function as a data transducer (see above cited patent application 9122242).

The data component illustrated in Figure 25 employs electronics as shown in Figure 18, but offers more diversified facilities than the component of Figure 19.

30   A larger readout window 3 permits alphanumeric information in both small and large lettering. Apart from the numbered manual data entry buttons (0-9), there are elongated data entry buttons such as button 15 (marked En), a double' arrow button for moving a cursor on the display screen to a desired position. Another square button 2d (marked U) is provided by which the

numbers 0 - 9 are lifted into an upper case, as it were, thereby acquiring a different meaning (see Table in, Figure 26). By pushing button 2d once, the number "1" acquires the meaning of a purchase code for purchasing stationeries. The user is aware that he has pressed button "U" because of the

5   visual indication provided by the three pin-size LED lamps 19. The lowest one stands for the lower case, the middle one for the upper case, and the third one for the "double upper case" level.

The third level is obtained when the button "U" is pressed twice. The three levels rotate with recurring push on button "U". Also, display window

10   indicators may be used to the same end.

The horizontally arranged buttons in, II, III and IV cannot be accessed without prior entry of a personal identifying number to give access to the respective memory sections containing credited sums of purchasing power. If the user wishes to get a visual display of the residual credit present in one of

15   the credit accounts in to IV, he may have to precede this by number, for example the number "9". If, then, immediately after entering the PIN the number 9 plus III is entered (which appears on the display window to assure correct entry) and thereafter the button En is pressed, the residual credit amount will become visible, based on the appropriate programming of the

20   microcomputer chip 1.

There are, furthermore, buttons marked alpha, beta and gamma, which, combined with number "9" produce a readout of the summed discounts resulting from purchases with discount stores alpha, or respectively, beta or gamma.

25   These sums may normally not be useable for general payments but only for purchases in the same stores who have offered the discounts. However, some stores may, in fact, offer discounts which do not need entry of a special code by the discount store's own terminal but may be used for executing a payment at any terminal. This latter arrangement can best be

30   implemented by arrangement with the store's bank, and would be handled like credits from banks in, II, III, etc.,' in other words, the user may draw from an Alpha Store by transferring .an amount to the so-called "money store" (see U.S. Patent No. 4,859,837).

According to the cited system, payments can be made from the money store without requiring prior entry of the PIN number. (The owner's personal secret number).

The keyboard shown in Figure 25 offers many more ways for personal financial management. The following examples can be considered directives for programming the "travel pass" and are part of this invention.

(a) The combination of a double upper case level, 2 x (U), with another of the alpha, beta or gamma buttons produces on the screen window, the last expenditure made. Upon pressing the button (say, ALPHA) again, the last-buttoned expenditure is displayed; after pressing ALPHA again, the expenditure of the preceding purchase appears. The user may continue along this line and review the successive expenditures stored' in the processor stack, and may write them down in his or her notebook. He may get the same result when selecting BETA but with the difference that any expenditure item displayed is deleted at the moment the next-earlier expenditure is selected. This way the stack is cleared in preparation for the next day's (or week's) expenditures.

Each stack row would display the following data: date of purchase, amount, classification code, and the account used for the purchase (i.e. in, II, III or IV)

(b) Another way of clearing the stack when the display indicates that it is full is to enter a sorting command. The card processor will then be directed to sum expenditures having the same classification code, and add the sum to the amount (if any) present at the same storage address containing already an amount constituting earlier summed expenditures of the same classification code. (See Table in, Figure 26). This procedure is repeated for all the ten classification codes. After that is done by the control circuit of the purse, the stack is cleared of all its data.

The above-mentioned "sorting command" might be entered by means of selecting a number other than 9, plus the upper case button (11). If such a command is not issued when the stack is full, the earliest purchase record at the bottom of the stack would be lost at the next purchase transaction which would be entered at the top of the stack.

(c) Still another method for dealing with the stack data is to make

its memory large enough for say 63, or even 127 purchases, but permit no further purchase transaction if the stack is full. The user must then present his/her purse for updating. That means, the purse must be connected with a bank computer of the owner's choice (if he has more than one credit account).

5 On this occasion, a printout is produced for all purchases contained in the enlarged stack by the bank equipment, and delivered by the bank to the user. After that, the entire stack is cleared by code signal from the bank. However, the first line of the stack is then used to receive from the bank computer the date of the update, its bank code, and location code from where 10 the update operation was done.

(d) One important automatic summation store, also managed by the "travel pass" processor is a fee payable with each update operation. The fee here referred to is not a bank charge (which may also be levied) but will be hire-purchase fee which is programmed to stop once the total amount has 15 been paid.

Say, the "travel pass" costs fifty pound sterling. Most people will prefer to buy it through fifty installment payments of one pound each payable every time an update operation is executed. When the summation store reaches fifty, further debits will cease. The banks receiving these amounts together 20 with an appropriate coding flag, will pass on these sums to the manufacturer or to the agents licensed to sell the "travel pass" devices.

A similar principle may be applied to insurance contributions which may be payable to guard against the contingency of inadvertently losing the "travel pass". The insurance premium payable with each update may be 10 pence, 25 or may be a small percentage of the' value turnover. The percentage, however, may increase with each incidence of loss affecting the same individual.

Electronic purses have no cash value to a finder except what he finds in the so-called "money store" the capacity of which would be kept small; even 30 this quasi cash value may not be available to a finder of the purse or pass because of the automatic return-to-credit function that a cautious user would always activate to become operative after a pre-selected time lapse (see further below). Most finders of a forgotten purse will therefore hand in the device to the nearest bank knowing that a reward will be payable to the finder

after contact has been made with the owner to ascertain the circumstances.

(e)   When a transfer is made from a selected credit 30 account (in, II, III, IV) of a portion of the residual credit to the so-called "money compartment" this invention provides for a time lapse command which the user may enter, ordering the purse processor after the expiry of the preset time lapse to return the residual amount in the "money compartment" of the memory to the credit account section of the "travel pass" from which section it had been derived. This command does not require a special command code if the entry of the time lapse is made immediately after the transfer of a sum from a credit account to the "money store". See flow diagram Figure 27.

From the example given in the flow diagram, the user wants the next payment to be made from credit transferred from his Account IV. The PIN had already been used for obtaining the display of the contents of the "money store". It has therefore not to be repeated for obtaining the display of the contents of credit store IV, namely 238.20 (in whatever currency).

The user enters 125.00 units for transfer to the "money store". After that, considering that the shopping trip will be finished in half an hour, the user enters 40 (minutes), then presses En for enactment. This will ensure that the money account will become empty after 40 minutes, whether anything was purchased or not.

(f) In order to prepare a purse or pass for an UPDATE, a PIN must be entered correctly. This invention provides in its programming the possibility for two different PINs being used, namely, one for all purchase and access transactions, and another for use only for update operations. Such a practice would still further increase the overall security for the account holders. After the PIN entry is successfully carried out, the user will select which of the accounts he wishes to update (in II, III, and IV). The display window will reflect the choice. This preparation also acts as an address selection for the purse sending out a dial signal over the telephone system to reach the respective bank computer center. This signal can only be sent out via field disturbances representing data if the "purse" or "pass" is presented to an appropriate reader unit.

There would be, according to this invention, two foremost locations where update terminals are installed. Firstly, in the banks which participate in

the "travel pass" scheme. Secondly, for remote fund transfer, there would be terminal units connected to the telephone network. Such units can be connected via the standard telephone switching system to the bank computer as "dialed" by the "travel pass". Long-distance and international codes,

5   however, must be dialed by the user himself before inserting the pass or purse into the proximity-coupled data transfer transducer of the phone network terminal. Once the pass establishes data contact with the bank computer concerned, a data dialogue is initiated strictly controlled by protocol during which various security check data are called up by the pass (including

10   data and time of the last update which remain stored in the pass) and if these data are in agreement with bank records, the depleted credit level in the "travel pass" is brought up to the level as arranged with the branch manager. The end of the transaction is indicated by a buzzing tone or the like, the user removes the pass from the terminal.

15   (g) The travel pass may also be used for storing different telephone numbers. Access to the selected telephone number is by viewing it on the display window of the travel pass after entering a first or second shift level (using button "U") combined with an easily remembered double digit number (for each frequently telephoned addressee). Telephones equipped with travel

20   pass readers may be built (both home phones and pay phones). When the travel pass is placed on the reader surface of such a telephone, the travel pass will pass on its instructions and the full dial number held in memory, responsive to the selected two-digit number.

(h) One of the advantages of a financial data carrier equipped with

25   data entry buttons is that the PIN, the secret personal identifying number, can be changed by its owner without reference to a central computer, and that such a change can be enacted virtually as soon as there is any suspicion that someone may have acquired knowledge of the code (see flow chart in Figure 27).

30   As a part of this invention, it is also proposed that a programming option is foreseen which would permit the owner of a purse to allow a friend or relative to know one of two PIN numbers, but not the other. The owner, however, would use the other PIN. The owner can also use the second PIN for changing the first PIN, whereas, the first PIN cannot be used for changing

any of the PINs. This provision can be achieved by appropriate hardware and software design.

Another feature according to the invention is the provision that the user may, if under duress to disclose any of the secret access numbers, use them or have them used by a third party but request an additional digit entry as part of the code which, if operated in a credit transfer with a bank, would cause an alarm to sound and also give the location of the pay phone terminal from which the update or transfer attempt is made. This is intended to enable law enforcement officers to appear on the scene quickly.

The Conventional Smart Card as a DataBase for the Smart Purse.

At this point the description of a smart purse or travel pass can be considered complete. It protects a card with fundamentally novel methods of data transfer, with due consideration to the diametrically opposite needs for strictly proximity transactions and where distances of several feet may have to be bridged. Where cards can remain handheld before, during and after a transaction. Where the programming takes account of the practical needs in public transport and other systems, and wherein the physical structure has been fairly narrowly defined.

However, there remains the problem of transition. The market is swamped with contact smart cards which require readers of a kind quite different from those described in this paper. If mass transport consultants recommended non-contact readers for transport applications, there would be no role for the contact smart cards in this area of application. The purpose of the final section of this paper is to show that contact smart cards can be a useful database for the versatile and fast-working travel pass.

The electrical connections for this combination are shown in Figure 20. It is possible to connect the serial output Pao of the microcomputer 1 with the in/o point of the card 8 because these are tri-state output/inputs and since there is a common clock CLK and a common program sequence, these states of these interface points can be programmed not to conflict with each other.

For purely internal readout operations and number transfers between storage sections, the clock pulses are derived from an oscillator in the interface section 6. However, when communicating with a terminal, the clock

pulse frequency is under the control of the terminal input. The circuit group 6 converts signals received by the antenna 7 for the field disturbance interpretable as data into logic levels binary signals. An example for this interface circuit is given in the co-pending patent applications Serial No.

5   9115403 or GB 1 314 021 or GB 2 075 732 B. Other examples are the F/2F binary data coding; the phase modulation of a carrier wave, frequency shift keying; and the use of infra-red receptors and transmitters. A battery 9 must be powerful enough to cover the current requirement of both the purse device and of the inserted smart card 8. The battery may be of the rechargeable

10   type so that solar cells such as may be mounted on the purse exterior may continually recharge the battery. The circuit group 5 is a 3 percent tolerant voltage stabilizer.

Figure 21 illustrates one version for applying a card to the purse device 10. At one end, a flat spring 13 is mounted to which is attached a pressure

15   pad (not seen). The same penetrates the shell 10 and partly blocks the internal slot area (12) so that a card cannot be introduced except by lifting the said flat spring 13 slightly. When the card is fully introduced, the spring blade 13 is released so that the same holds the card in position and the card can now be read by the purse electronics via the contact pad 14.

20   Another way of putting a smart card into a functional relationship with the smart purse is shown in Figures 22, 23 and 24. The rear of the main frame 10 is covered by a metal lid 20 hinged at the upper end on an axle 22 held by flanges 10f. The lower edge 20a bears during the closing action against the thickened end 21a of a springy metal angle 21. With additional

25   pressure, the latter gives way and the lid can be snap-closed.

To insert a card 8, the lid 20 is opened; the card inserted as shown; and the lid 20 fully closed again. An elastic pressure pad on the inside of the lid holds the card against the flat surface 10k. To improve the manual grip of the hand on the lid 20 when opening it, the main body 10 is slightly recessed

30   on both sides on the middle area of the device; these recessed portions are marked 10g. Alternative means may achieve the same end.

Contact with the metal pad 14 of the card 8 is made by platen-tipped, spring-loaded pointed pins 23 as shown in Figure 24 about four times enlarged. The tiny coil spring 24 as shown in Figure 24 is also used as a wire

24a to establish continuity between the corresponding segment of the card contact pad 14 and the card electronics. The tiny coil spring 24 and the contractor pin 23 are retained in the hole of the central main plate 10h by a bottom plate 10l and a top plate 10k. Tolerances must be close to avoid any dirt to enter the pinhole. The precision hole drilled in the cover plate 10k will ensure good moving fit for the contact pins 23.

The lid 20 may be used as a capacitive antenna for sending and receiving data to and from a travel pass communication terminal or Reader unit. Any of the techniques discussed in the first part of this paper may be employed.

The hybrid solution here presented for using simultaneously a contact smart card and an electronic purse (i.e., travel pass) could be usefully employed by persons who have several smart credit cards each holding credit from a different bank or building society, etc. The versatility and convenience of a handheld payment instrument such as the travel pass could thus be made available to other card technology.

The invention having been thus described, it will be apparent to those skilled in the art that the same may be varied in many ways without departing from the spirit and scope of the invention. Any and all such modifications are intended to be encompassed within the following claims: